CLAIMS

1. An electromagnetic wave generator comprising:

a first pump beam emitter configured to emit a first pump beam having a wavelength larger than one micrometer;

a second pump beam emitter configured to emit a wavelength-tunable second pump beam having a wavelength larger than one micrometer, the wavelength of which is different from the wavelength of the first pump beam;

a nonlinear optical crystal configured to generate an electromagnetic wave of a difference frequency between the first and second pump beams; and

an optical system configured to irradiate the first and second pump beams to the nonlinear optical crystal, by adjusting an external intersection angle between the first and second pump beams within 0.5° at the difference frequency of 1 THz,

wherein a frequency-tunable terahertz electromagnetic wave is generated in the nonlinear optical crystal, by changing the frequency of the second pump beam, being liked with the change of the external intersection angle.

2. The electromagnetic wave generator of claim 1, wherein the nonlinear optical crystal is GaP crystal, $ZnGeP_2$ crystal, or GaSe crystal.

3. The electromagnetic wave generator of claim 1, wherein

the first pump beam emitter emits an output of a YAG laser at wavelength of 1.064 micrometers as the first pump beam; and

the second pump beam emitter comprises an optical parametric oscillator equipped with an injection-seeding mechanism so as to emit an output of the optical parametric oscillator as the second pump beam, the optical parametric oscillator is excited by the output of the YAG laser.

4. The electromagnetic wave generator of claim 1, wherein:

the first pump beam emitter comprises a first pump source implemented by any one of Cr-doped forsterite laser, ytterbium-doped yttrium-lithium-fluoride laser, and ytterbium-doped fiber laser, configured to emit the first pump beam; and

the second pump beam emitter comprises a second pump source implemented by any one of Cr-doped forsterite laser, ytterbium-doped yttrium-lithium-fluoride laser, and ytterbium-doped fiber laser , configured to emit the second pump beam.

5. The electromagnetic wave generator of claim 4, further comprising an excitation light source configured to excite the first and second pump sources so as to emit the first and second pump beams from the first and second pump sources, respectively

6. The electromagnetic wave generator of claim 5, further comprising a timing control mechanism configured to control arrival timings of pulses of the first and second pump beams to the nonlinear optical crystal.

7. An electromagnetic wave generator comprising:

a first pump beam emitter configured to emit a first pump beam;

a second pump beam emitter configured to emit a wavelength-tunable second pump beam, the wavelength of which is different from the wavelength of the first pump beam; and

a nonlinear optical crystal configured to generate an electromagnetic wave of a difference frequency between the first and second pump beams,

wherein a frequency-tunable terahertz electromagnetic wave is generated in the nonlinear optical crystal, by changing the frequency of the second pump beam.

8. The electromagnetic wave generator of claim 7, wherein:

the first pump beam emitter comprises a first pump source implemented by any one of Cr-doped forsterite laser, ytterbium-doped yttrium-lithium-fluoride laser, and ytterbium-doped fiber laser, configured to emit the first pump beam;

a second pump beam emitter comprises a second pump source implemented by any one of Cr-doped forsterite laser, ytterbium-doped yttrium-lithium-fluoride laser, and ytterbium-doped fiber laser, configured to emit the second pump beam.

9. The electromagnetic wave generator of claim 7, wherein the nonlinear optical crystal is $ZnGeP_2$ crystal or GaSe crystal.

10. An electromagnetic wave generator comprising:

a first pump beam emitter configured to emit a first pump beam;

a second pump beam emitter configured to emit a wavelength-tunable second pump beam, the wavelength of which is different from the wavelength of the first pump beam;

a nonlinear optical crystal configured to generate an electromagnetic wave of a difference frequency between the first and second pump beams;

an optical system configured to irradiate the first and second pump beams to the nonlinear optical crystal, by adjusting an external intersection angle between the first and second pump beams; and

a timing control mechanism configured to control arrival timing of pulses of the first and second pump beams to the nonlinear optical crystal,

wherein a frequency-tunable terahertz electromagnetic wave is generated in the nonlinear optical crystal, by changing the frequency of the second pump beam, being liked with the change of the external intersection angle.

11. The electromagnetic wave generator of claim 10, wherein:

the first pump beam emitter comprises a first pump source implemented by any one of Cr-doped forsterite laser, ytterbium-doped yttrium-lithium-fluoride laser, and ytterbium-doped fiber laser, configured to emit the first pump beam;

a second pump beam emitter comprises a second pump source implemented by any one of Cr-doped forsterite laser, ytterbium-doped yttrium-lithium-fluoride laser, and ytterbium-doped fiber laser, configured to

emit the second pump beam.

12. The electromagnetic wave generator of claim 11, wherein the timing control mechanism controls the timing by adjusting time lag between excitation light pulses configured to excite the first and second light sources, respectively.

13. The electromagnetic wave generator of claim 11, wherein the timing control mechanism comprises a double pulse YAG laser including:

a first YAG rod configured to excite the first pump source; and

a second YAG rod configured to excite the second pump source, wherein the timing is controlled by adjusting time lag between an excitation light pulse from the first YAG rod and another excitation light pulse from the second YAG rod.

14. The electromagnetic wave generator of claim 10, further comprising:

a beam splitter configured to divide a beam of terahertz electromagnetic wave being emitted from the nonlinear optical crystal; and

a feedback detector configured to feed back detected output to the timing control mechanism, by detecting an intensity of the divided beam,

wherein the timing control mechanism controls the timing so as to maximize the detected output.

15. An electromagnetic wave generator comprising:

a first pump beam emitter configured to emit a first pump beam;

a second pump beam emitter configured to emit a wavelength-tunable second pump beam, the wavelength of which is different from the wavelength of the first pump beam;

a nonlinear optical crystal configured to generate an electromagnetic wave of a difference frequency between the first and second pump beams, and to emit the electromagnetic wave from an electromagnetic wave exit face;

an optical system configured to irradiate the first and second pump beams to the nonlinear optical crystal, by adjusting an external intersection angle between the first and second pump beams; and

an angle control mechanism configured to control an angle of the electromagnetic wave exit face against an optical axis of the first pump beam,

wherein a frequency-tunable terahertz electromagnetic wave is emitted from the electromagnetic wave exit face, by changing the frequency of the second pump beam, being liked with the change of the external intersection angle and the change of the angle of the electromagnetic wave exit face.

16.The electromagnetic wave generator of claim 15, further comprising:

a first off-axial paraboloid reflector configured to reflect the electromagnetic wave emitted from the electromagnetic wave exit face;

a second off-axial paraboloid reflector configured to move on a linear stage against the first off-axial paraboloid reflector, reflecting the electromagnetic wave reflected by the first off-axial paraboloid reflector; and

a position controller configured to control position of the second off-axial paraboloid reflector so that the electromagnetic wave emitted with a specific exit angle against the electromagnetic wave exit face can focus into an arbitrary point, irrespective of the exit angle.

17. The electromagnetic wave generator of claim 15, further comprising:

a rotatable first incident mirror configured to reflect the first pump beam so as to adjust an incident angle with which the first pump beam irradiates to the nonlinear optical crystal;

a rotatable second incident mirror configured to reflect the second pump beam so as to adjust another incident angle with which the second pump beam irradiates to the nonlinear optical crystal;

a terahertz-generator rotation stage on which the first and second incident mirrors are mounted, configured to turn around on an exit point, defining the exit point as a central axis of the rotation,

wherein the electromagnetic wave emitted with a specific exit angle against the electromagnetic wave exit face is controlled to focus into an arbitrary point, irrespective of the exit angle, by rotating the terahertz-generator rotation stage.

18. The electromagnetic wave generator of claim 15, wherein the nonlinear optical crystal is any one of GaP crystal, $ZnGeP_2$ crystal, and GaSe crystal.

19. The electromagnetic wave generator of claim 15, wherein

the first pump beam emitter emits an output of a YAG laser at

wavelength of 1.064 micrometers as the first pump beam; and

the second pump beam emitter comprises an optical parametric oscillator equipped with an injection-seeding mechanism so as to emit an output of the optical parametric oscillator as the second pump beam, the optical parametric oscillator is excited by the output of the YAG laser.

20. The electromagnetic wave generator of claim 15: wherein

the first pump beam emitter comprises a first pump source implemented by any one of Cr-doped forsterite laser, ytterbium-doped yttrium-lithium-fluoride laser, and ytterbium-doped fiber laser, configured to emit the first pump beam;

a second pump beam emitter comprises a second pump source implemented by any one of Cr-doped forsterite laser, ytterbium-doped yttrium-lithium-fluoride laser, and ytterbium-doped fiber laser, configured to emit the second pump beam.